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(54) LOW-MELTING OPTICAL GLASS

(57)Abstract:
PURPOSE: To obtain the subject glass having high refractive index and high dispersion characteristics, enabling itself to be press molded at relatively low temperatures by specifying the amounts of the respective components in P2O5- Na2O-Nb2O5-WO3-based or P2O5-B2O3-Li2O-Na2O-Nb2O5-based phosphate glass.
CONSTITUTION: The 1st embodiment: a glass feedstock composition comprising 2-29wt.% of P2O5, 2-25wt.% of Na2O, 4-22wt.% of Nb2O5, 20-52wt.% of WO3 and a specified weight range of any other desired component is melted by heating at 1000-1200° C, clarified, homogenized by agitation, cast and then annealed, thus gives the objective optical glass having the following characteristics such as refractive index of 1.70-1.86, dispersive power of 35-21 and glass yield point of ≤570° C. The 2nd embodiment: a glass feedstock composition comprising 12-32wt.% of P2O5, 0.5-16wt.% of B2O3, 0.3-6wt.% of Li2O, 2-22wt.% of Na2O, 8-52wt.% of Nb2O5 and a specified weight range of any other desired component is subjected to the same processes as those mentioned above to obtain the objective optical glass having the following characteristics such as refractive index of 1.69-1.83, dispersive power of 32-21 and glass yield point of ≤570° C.

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(54)【発明の名称】 低融点光学ガラス

(57)【要約】
【目的】 より高屈折率及び高分散特性を有するとともに、低い温度でガラスが失透せずに軟化してプレス成形することが可能であり、かつ液相温度が低く安定性に優れた光学ガラスの提供。
【構成】 重量％で表示して、P_2O_5を２～２９％、Na_2Oを２～２５％、Nb_2O_5を４％以上２２％未満、WO_3を２０～５２％含むことを特徴とする低融点光学ガラス。このガラスは、屈折率が１．７０～１．８６、分散率が２１～３５、ガラス屈伏点が５７０℃以下である。重量％で表示して、P_2O_5を１２～３２％、B_2O_3を０．５～１６％、Li_2Oを０．３～６％、Na_2Oを２～２２％、Nb_2O_5を８～５２％含むことを特徴とする低融点光学ガラス。このガラスは、屈折率が１．６９～１．８３、分散率が２１～３２、ガラス屈伏点が５７０℃以下である。

【特許請求の範囲】

【請求項1】 重量%で表示して、P_2O_5を2～29%、Na_2Oを2～25%、Nb_2O_5を4%以上22%未満、WO_3を20～52%含むことを特徴とする低融点光学ガラス。

【請求項2】 屈折率n_dが1.70～1.86の範囲であり、分散率ν_dが35～21の範囲であり、かつガラス屈伏点（Ts）が570℃以下である請求項1に記載の低融点光学ガラス。

【請求項3】 重量%で表示して、P_2O_5を12～32%、B_2O_3を0.5～16%、Li_2Oを0.3～6%、Na_2Oを2～22%、Nb_2O_5を8～52%含むことを特徴とする低融点光学ガラス。

【請求項4】 屈折率n_dが1.69～1.83の範囲であり、分散率ν_dが32～21の範囲であり、かつガラス屈伏点Tsが570℃以下である請求項3に記載の低融点光学ガラス。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、低温度でプレスすることができ、非球面精密プレス用として有用な低融点光学ガラスに関する。

【0002】

【従来の技術】従来の高屈折率、高分散を示す光学ガラスとしては、例えばP_2O_5－Nb_2O_5－アルカリ金属酸化物系ガラス（特公昭56－40094号公報）がある。さらに、SiO_2－TiO_2－Nb_2O_5－アルカリ金属酸化物系ガラス（特開昭63－265840号公報）も高屈折率、高分散を示す光学ガラスである。しかし、これらのガラスの屈伏温度（Ts）は600℃以上と高い。通常、精密プレス成形は、屈伏温度（Ts）より30℃～50℃高い温度で行なわれる。よって、上記のガラスを精密プレス成形する場合、プレス温度は650℃～700℃の範囲となる。ところが、このような高温でプレスを繰り返し行うと、型材の劣化が著しく、プレス開始後、比較的短時間の内に精密なガラス面が得られなくなってしまう。そこで、精密なガラス面を得るためには型の交換を頻繁に行う必要があるが、それでは精密レンズを量産することは非常に困難である。

【0003】このような観点から、精密プレスレンズ製造における型の寿命を延長するための1つの策として、屈伏温度（Ts）の低いガラスを用いることが挙げられる。例えば、特開平1－308843号公報には、高屈折率、高分散を示す低融点光学ガラスであるSiO_2－PbO－アルカリ金属酸化物系のガラスが開示されている。さらに、特開平5－51233号公報には、高屈折率、高分散を示す低融点光学ガラスであるSiO_2－GeO_2－TiO_2－Nb_2O_5－アルカリ金属酸化物系のガラスが開示されている。

【0004】

【発明が解決しようとする課題】しかしながら、これらの特許公報に記載のガラスにはいくつかの問題点があった。例えば、特開平1－308843号記載のガラスは多量の酸化鉛を含んでいる。一方、ガラスのプレスは、通常、型の酸化を防ぐために還元性雰囲気で行われる。そのため、上記酸化鉛含有ガラスの場合、ガラス中の酸化鉛が還元性雰囲気中で還元されて金属鉛が表面に析出する。析出した金属鉛は、型表面に付着して、ガラスをプレスする際にガラス表面に凸凹をつくり、面精度が悪くなってしまう。それに対して特開平5－51233号に記載のガラスは、ガラス成分中にPbOを含まない低融点光学ガラスである。しかし、このガラスは液相温度が高く、軟化温度付近での失透傾向も強い。そのため、ガラスプリフォームを昇温して軟化させ、精密プレス成形をするのは困難であり、プレスレンズの製造には適さない。

【0005】そこで本発明の目的は、高屈折率及び高分散特性を有するとともに、低い温度でガラスが失透せずに軟化してプレス成形することが可能であり、かつ液相温度が低く安定性に優れた光学ガラスを提供することにある。

【0006】

【課題を解決するための手段】本発明の第1の態様の光学ガラスは、重量%で表示して、P_2O_5を2～29%、Na_2Oを2～25%、Nb_2O_5を4以上22%未満、WO_3を20～52%含むことを特徴とする低融点光学ガラスに関する。

【0007】本発明の第2の態様の光学ガラスは、重量%で表示して、P_2O_5を12～32%、B_2O_3を0.5～16%、Li_2Oを0.3～6%、Na_2Oを2～22%、Nb_2O_5を8～52%含むことを特徴とする低融点光学ガラスに関する。

【0008】以下、まず、本発明の第1の態様の光学ガラスについて、各成分およびその含量の限定理由を説明する。P_2O_5は燐酸塩ガラスにおいてガラス形成成分として欠かせない成分である。燐酸塩ガラスは珪酸塩ガラスと比べて低い温度でガラスを溶融することができ、可視域の透過率が高いという特徴をもつ。また同じガラス形成酸化物成分であるSiO_2やB_2O_3に比べてP_2O_5は高分散側に位置する成分のため、アッベ数35以下の光学特性を得るには、P_2O_5は少なくとも2%は必要である。逆に29%を越えると失透性が強くなり、安定なガラスが得られなくなる。そのため、P_2O_5の含量は2～29%に限定される。好ましいP_2O_5の含量は4～26%の範囲である。

【0009】Na_2Oはガラスの屈伏温度（Ts）を下げ、液相温度を下げる成分として欠かせない成分である。またガラスの粘性を下げることができるので低温で溶解が可能となり、白金るつぼの浸食による着色を抑えることができる。Na_2Oが2%未満では失透性が強く

上記の効果が得られない。また２５％を越えると、耐失透性、化学的耐久性が悪くなる。従ってNa$_2$Oの含量は2～２５％に限定され、好ましくは４～２２％である。

【００１０】Nb$_2$O$_5$は、目的とする高屈折率、高分散特性を得るために不可欠な成分であり、また耐久性を上げる効果のある成分でもある。Nb$_2$O$_5$が４％未満であると目的とする高屈折率・高分散特性が得られなくなり、２２％以上では耐失透性が悪くなり、ガラスの屈伏点（Ｔｓ）が上昇する。このためNb$_2$O$_5$は４％以上２２％未満に限定される。好ましいNb$_2$O$_5$の含量は6～２１．５％である。

【００１１】WO$_3$は目的とする高屈折率・高分散特性を得るために不可欠な成分であり、またガラスの屈伏点（Ｔｓ）を下げるのに非常に有効な成分である。WO$_3$が２０％未満であると目的とする高屈折率・高分散特性が得られなくなり、ガラスの屈伏点も上昇する。また５２％を越えると耐失透性が悪くなり、かつガラスが強く着色することになる。このためWO$_3$は２０～５２％に限定される。好ましいWO$_3$の含量は２３～４９％である。

【００１２】本発明の第１の態様の低融点光学ガラスは、後述の実施例からも明らかなように高屈折率で高分散特性を有し、かつ低融点特性を有している。例えば屈折率は１．７０～１．８６の範囲にあり、アッベ数は３５～２１の範囲でガラス屈伏点（Ｔｓ）は５７０℃以下の範囲である。また液相温度（Ｌ・Ｔ）を下げることができ、かつガラス塊をプレスする際のガラス軟化点での失透性も従来品よりも優れている。

【００１３】本発明の第１の態様の低融点光学ガラスは、前記成分以外に任意成分として更に、B$_2$O$_3$、GeO$_2$、Li$_2$O、K$_2$O、Cs$_2$O、MgO、CaO、SrO、BaO、ZnO、TiO$_2$、Ta$_2$O$_5$、As$_2$O$_3$、Sb$_2$O$_3$等の成分を含むことができる。これら任意成分の含量は、重量％で表示して、B$_2$O$_3$が0～１５％、GeO$_2$が0～２７％、Li$_2$Oが0～４％、K$_2$Oが0～１５％、Cs$_2$Oが0～５％、MgOが0～５％、CaOが0～５％、SrOが0～５％、BaOが0～１５％、ZnOが0～７％、TiO$_2$が0～１６％、Ta$_2$O$_5$が0～７％、As$_2$O$_3$が0～２％、Sb$_2$O$_3$が0～２％の範囲である。以下にその理由を説明する。

【００１４】B$_2$O$_3$及びGeO$_2$は、ガラスの安定性を上げる効果が非常に大きな成分である。しかし、B$_2$O$_3$は１５％を越え、GeO$_2$は２７％を越えると、目的とする高屈折率・高分散特性が得られなくなり、またガラスの屈伏点も上昇する。そのためB$_2$O$_3$の含量は0～１５％の範囲に、GeO$_2$は0～２７％の範囲に限定される。好ましくは、B$_2$O$_3$は0～１３％の範囲であり、GeO$_2$は0～２５％の範囲である。

【００１５】Li$_2$O、K$_2$O及びCs$_2$Oは、ガラスの屈伏温度（Ｔｓ）を下げる効果が非常に大きな成分である。しかし、Li$_2$Oは４％を越え、K$_2$Oは１５％を越え、Cs$_2$Oは５％を越えると、それぞれ耐失透性、化学的耐久性が悪化する。そのためLi$_2$Oは0～４％の範囲、K$_2$Oは0～１５％の範囲、Cs$_2$Oは0～５％の範囲に限定される。好ましくは、Li$_2$Oは0～２％の範囲、K$_2$Oは0～１３％の範囲、Cs$_2$Oは0～３％の範囲である。

【００１６】アルカリ土類金属酸化物であるMgO、CaO、SrO及びBaOはガラスの液相温度を下げ、安定性を増す効果が大きな成分である。しかし、MgOは５％を越え、CaOは５％を越え、SrOは５％を越え、BaOは１５％を越えると、目的とする高屈折率・高分散特性が得られず、かつ耐失透性が悪くなる。このためMgO、CaO及びSrOの含量は、それぞれ0～５％の範囲に限定され、BaOは0～１５％の範囲に限定される。好ましくは、MgO、CaO及びSrOはそれぞれ0～３％の範囲であり、BaOは0～１３％の範囲である。

【００１７】TiO$_2$は高屈折率・高分散特性を得る効果が大きい成分である。しかし、１６％を越えると耐失透性が悪くなり、ガラスの屈伏点が上昇し、強く着色することがある。そのため、TiO$_2$の含量は、0～１６％の範囲である。

【００１８】ZnO及びTa$_2$O$_5$は、耐失透性を損なわずに少量添加により屈折率の調整をすることが可能である。しかし、それぞれ７％を越えると耐失透性が悪くなる。そのため、ZnO及びTa$_2$O$_5$の含量は、いずれも0～７％の範囲に限定され、好ましくは0～５％の範囲である。

【００１９】As$_2$O$_3$及びSb$_2$O$_3$は消色剤および溶融剤として有効である。しかし、いずれも２％を越えて添加すると耐失透性を悪くする。そのため、As$_2$O$_3$及びSb$_2$O$_3$の含量は、それぞれ0～２％の範囲に限定される。尚、本発明の第１の態様の光学ガラスは、本発明の目的を損なわない範囲で、上記の成分以外の成分を含有することもできる。

【００２０】次に、本発明の第２の態様の光学ガラスについて、各成分およびその含量の限定理由を説明する。P$_2$O$_5$は燐酸塩ガラスにおいて、ガラス形成成分として欠かせない成分である。燐酸塩ガラスは珪酸塩ガラスと比べて低い温度でガラスを溶融することができ、可視域の透過率が高いという特徴をもつ。また同じガラス形成酸化物成分である、SiO$_2$やB$_2$O$_3$に比べてP$_2$O$_5$は高分散側に位置する成分のためアッベ数３２以下の光学特性を得るにはP$_2$O$_5$は少なくとも１２％は必要である。逆に３２％を越えると失透性が強くなり、安定なガラスが得られなくなるためP$_2$O$_5$の含量は１２～３２％の範囲に限定される。好ましいP$_2$O$_5$の含量

は14～30%の範囲である。

【0021】B_2O_3は燐酸塩ガラスにおいて適量添加により耐失透性が極めて良くなり、かつ、P_2O_5、SiO_2といった他のガラス形成酸化物成分に比べてガラス屈伏点（Ts）を下げる効果が大きい。そのため、本発明には欠かせない成分である。B_2O_3が0．5%未満であると上記のごとく耐失透性が悪くなり、ガラスの屈伏点（Ts）が上昇し、16%を越えると目的とする高屈折率・高分散特性が得られなくなる。このためB_2O_3は0．5～16%の範囲に限定される。好ましいB_2O_3の含量は1～14%の範囲である。

【0022】Li_2Oは、目的とするガラス屈伏点（Ts）が570℃以下の低融点特性を得るために不可欠な成分である。Li_2Oが0．3%未満であると目的とする低融点特性が得られなくなり、6%を越えると耐失透性が悪くなる。このためLi_2Oは0．3～6%の範囲に限定される。好ましいLi_2Oの含量は0．3～4%の範囲である。

【0023】Na_2Oはガラスの屈伏温度（Ts）を下げ、液相温度を下げる成分として欠かせない成分である。またガラスの粘性を下げることができるので低温で溶解が可能となり、白金るつぼの浸食による着色を抑えることができる。Na_2Oが2%未満では失透性が強く上記の効果が得られない。また22%を越えると、耐失透性、化学的耐久性が悪くなる。従ってNa_2Oの含量は2～22%の範囲に限定され、好ましくは4～20%の範囲である。

【0024】Nb_2O_5は、目的とする高屈折率・高分散特性を得るために不可欠な成分であり、また耐久性を上げる効果のある成分である。Nb_2O_5が8%未満であると目的とする高屈折率・高分散特性が得られなくなり、52%を越えると耐失透性が悪くなり、かつガラスの屈伏点（Ts）が上昇する。このためNb_2O_5は8～52%の範囲に限定される。好ましいNb_2O_5の含量は10～50%の範囲である。

【0025】本発明の第2の態様の低融点光学ガラスは、後記の実施例からも明らかなように高屈折率で高分散特性を有し、かつ低融点特性を有している。例えば、屈折率は1．69～1．83の範囲にあり、アッベ数は32～21の範囲でガラス屈伏点（Ts）は570℃以下の範囲である。また、液相温度（L・T）を下げることができ、かつガラス塊をプレスする際のガラス軟化点での失透性も従来品よりも優れている。

【0026】本発明の第2の態様の低融点光学ガラスは、前記成分以外に任意成分として更に、SiO_2、GeO_2、K_2O、MgO、CaO、SrO、BaO、ZnO、Al_2O_3、TiO_2、Ta_2O_5、WO_3、As_2O_3、Sb_2O_3等の成分を含むことができる。これら任意成分の含量は、重量%で表示して、SiO_2が0%～5%、GeO_2が0～12%、K_2Oが0～12%、K_2Oが0～12%、MgOが0～5%、CaOが0～5%、SrOが0～5%、BaOが0～12%、ZnOが0～5%、Al_2O_3が0～5%、TiO_2が0～12%、Ta_2O_5が0～5%、WO_3が0%以上20%未満、As_2O_3が0～2%、Sb_2O_3が0～2%である。

【0027】SiO_2及びGeO_2は、ガラスの安定性を上げる効果が非常に大きな成分である。しかし、SiO_2が5%を越え、GeO_2が12%を越えると目的とする高屈折率・高分散特性が得られなくなり、またガラスの屈伏点も上昇する。このためSiOの含量は0%～5%、GeO_2は0～12%の範囲に限定される。好ましくは、SiO_2は0～4．5%の範囲、GeO_2は0～10%の範囲である。

【0028】K_2Oはガラスの屈伏点（Ts）を下げる効果が非常に大きな成分である。しかし、K_2Oが12%を越えると耐失透性、化学的耐久性が悪化する。そのためK_2Oは0～12%の範囲に限定される。好ましいK_2Oの含量は0～10%の範囲である。

【0029】アルカリ土類金属酸化物であるMgO、CaO、SrO及びBaOはガラスの液相温度を下げ安定性を増す効果が大きな成分である。しかし、MgOは5%を越え、CaOは5%を越え、SrOは5%を越え、BaOは12%を越えると、目的とする高屈折率・高分散特性が得られず、かつ耐失透性が悪くなる。このためMgO、CaO及びSrOの含量は、いずれも0～5%の範囲に限定され、BaOは0～12%の範囲に限定される。好ましくは、MgO、CaO及びSrOはそれぞれ0～3%の範囲であり、BaOは0～10%の範囲である。

【0030】TiO_2及びWO_3は高屈折率・高分散特性を得る効果が大きい成分である。しかし、TiO_2は12%を越え、WO_3は20%以上になると、耐失透性が悪くなり、ガラスの屈伏点が上昇し、強く着色するようになる。このためTiO_2は0～12%の範囲に限定され、WO_3は0%以上20%未満に限定される。好ましくは、TiO_2は0～10%の範囲で、WO_3は0～19．5%範囲である。

【0031】ZnO、Ta_2O_5及びAl_2O_3は、耐失透性を損なわずに少量添加により、屈折率の調整をすることが可能な成分である。しかし、それぞれ5%を越えると耐失透性が悪くなる。そのため、それぞれの含量は0～5%の範囲に限定され、好ましくは0～3%の範囲である。

【0032】As_2O_3及びSb_2O_3は、消色剤および清澄剤として有効である。しかし、2%を越える量の添加は耐失透性を悪くする。そのため、As_2O_3及びSb_2O_3の含量はそれぞれ0～2%の範囲に限定される。尚、本発明の第2の態様の光学ガラスは、本発明の目的を損なわない範囲で、上記の成分以外の成分を含有

することもできる。

【００３３】本発明の低融点光学ガラスは、第１の態様及び第２の態様いずれの場合も、原料として、P_2O_5は正燐酸（H_3PO_4）、メタリン酸塩、五酸化二燐等、他の成分については炭酸塩、硝酸塩、酸化物等を適宜用いることが可能である。これらの原料を所望の割合に秤取し、混合して調合原料とし、これを１０００℃～１２００℃に加熱した熔解炉に投入し、熔解、消澄後、撹拌し、均一化してから鋳型に鋳込み徐冷することにより、本発明の低融点光学ガラスを得ることができる。

【００３４】

【実施例】以下、実施例によりさらに本発明について説明する。

実施例１～１４

本発明の低融点光学ガラス（第１の態様）の調合組成（重量%）及び光学的性能を表１及び２に示す。各ガラスの原料は、P_2O_5の場合H_3PO_4であり、Na_2Oの場合Na_2CO_3であり、K_2Oの場合KNO_3であり、Li_2Oの場合Li_2CO_3であり、Cs_2Oの場合Cs_2CO_3であり、MgOの場合$MgCO_3$であり、CaOの場合$CaCO_3$であり、SrOの場合$Sr(NO_3)_2$であり、BaOの場合$BaCO_3$であり、B_2O_3の場合H_3BO_3であり、その他の成分については、表１及び２に示した酸化物をそのまま使用した。表１及び２の実施例１～１４に示した各ガラスは、定められた組成に調合した後、白金坩堝を用いて１０００℃～１２００℃で熔解した。３０～４０分熔解し均質化した後、金型に鋳込み徐冷することによりガラスを得た。

【００３５】表中の屈折率（n_d）、アッベ数（ν_d）は徐冷降温速度－３０℃／ｈｒにした場合の結果である。ガラス転移点Ｔｇ、ガラス屈伏点（Ｔｓ）は熱膨張測定機を用いて８℃／ｍｉｎで昇温した場合の測定結果である。液相温度（Ｌ・Ｔ）は４００℃～１０５０℃の温度勾配のついた失透試験炉に３０分保持し、倍率８０倍の顕微鏡により結晶の有無を観察し、軟化点付近の失透性も液相温度測定の際同時に目視により観察した結果である。

【００３６】

【表１】

	実施例						
	1	2	3	4	5	6	7
P_2O_5	4.4	24.4	17.4	14.4	18.4	19.4	15.4
B_2O_3	2.5	2.5	12.5	—	1.0	2.5	5.5
GeO_2	24.0	8.0	8.0	8.0	—	4.0	4.0
Na_2O	7.8	10.0	10.0	10.0	5.0	20.0	10.0
K_2O	—	3.8	0.8	—	7.8	2.8	12.8
BaO	5.0	5.0	5.0	11.8	—	3.0	3.0
TiO_2	5.0	2.0	5.0	4.5	—	6.0	6.0
Nb_2O_5	12.6	9.1	7.6	10.6	21.1	16.6	12.6
WO_3	38.7	35.2	33.7	38.7	46.7	25.7	30.7
Li_2O				2.0			
As_2O_3					0.2		
Sb_2O_3						0.2	
Cs_2O							
MgO							
CaO							
SrO							
ZnO							
Ta_2O_5							
n_d	1.85225	1.70266	1.72277	1.77908	1.80025	1.72361	1.70035
ν_d	21.8	32.3	26.5	25.4	23.33	34.5	29.13
Tg	502	494	479	442	539	453	404
Ts	534	533	529	475	568	489	444
L・T	940	認めず	850	800	900	830	730
軟化点失透性	透明	透明	透明	透明	透明	透明	透明

【0037】

【表2】

	実施例						
	8	9	10	11	12	13	14
P_2O_5	18.4	13.4	17.4	13.4	17.4	16.4	18.4
B_2O_3	2.5	1.0	2.5	1.0	3.5	2.5	—
GeO_2	4.0	8.0	4.0	8.0	4.0	8.0	—
Na_2O	17.0	10.0	10.0	10.8	10.0	10.0	10.0
K_2O	2.8	0.8	2.8	—	2.8	0.8	2.8
BaO	3.0	8.0	6.0	8.0	—	5.0	—
TiO_2	6.0	4.5	6.0	4.5	6.0	13.0	3.0
Nb_2O_5	12.6	12.6	12.6	12.6	12.6	10.6	16.1
WO_3	30.7	38.7	35.7	38.7	39.7	33.7	45.7
Li_2O							
As_2O_3							
Sb_2O_3							
Ce_2O	3.0						
MgO		3.0					
CaO			3.0				
SrO				3.0			
ZnO					4.0		
Ta_2O_5							4.0
n_d	1.70815	1.79671	1.79909	1.80215	1.79765	1.84190	1.82682
ν_d	31.3	26.49	24.56	24.76	23.74	22.7	22.27
Tg	411	489	515	487	494	532	511
Ts	448	515	547	515	527	568	549
L・T	800	890	750	780	793	950	850
軟化点失透性	透明	透明	透明	透明	透明	透明	透明

【0038】比較例1～11

特公昭56－40094号公報に記載の実施例7と14のガラスを比較用ガラスとして、その屈折率、アッベ数、液相温度、ガラス屈伏点（Ts）を測定した。結果を表3（比較例1、比較例2）に示す。この比較ガラスはNb_2O_5を多く含んでいるため、耐失透性が悪くガラス屈伏点も600℃以上と精密プレス成形用ガラスとしては実用的でないことがわかる。比較例3のガラスは、特開昭63－265840号公報に記載の実施例4のガラスの屈折率、アッベ数、液相温度（L・T）、ガラス屈伏点（Ts）を測定した結果である（表3）。このガラスもガラス屈伏点が622℃と高く、軟化点付近で30分間保持するとガラスが失透してしまうため、実用的でないことがわかる。比較例4のガラスは、特開平1－308843号公報に記載の実施例29のガラスの屈折率、アッベ数、ガラス屈伏点（Ts）を測定した結果である（表3）。このガラスはガラス屈伏点が428℃と非常に低いが、PbOを多量に含むため還元性雰囲気でガラスをプレスするとPbOが還元され型に付着し、その後精密プレスが不可能となり実用的でないことがわかる。

【0039】比較例5～11（表3及び4）のガラスは、特開平5－51233号公報に記載の実施例1、2、3、4、5、6、8のガラスの屈折率、アッベ数、ガラス屈伏点（Ts）を測定した結果である。これらのガラスはガラス熔解中にガラスが失透したり、熔解後キャストしてガラスになったものでも液相温度は1000℃以上と高く、軟化点付近で30分間保持するとガラス

が失透してしまうため、いずれも実用的でないことが分かる。

【0040】

【表3】

	比較例					
	1	2	3	4	5	6
P_2O_5	31.3	19.4	3.5			
B_2O_3			1.5	15.0	5.0	
GeO_2					7.0	15.0
SiO_2			22.0	15.0	12.0	10.0
Li_2O				4.0	1.3	
Na_2O					10.7	15.0
K_2O	16.2	12.8	20.0		7.5	3.0
Cs_2O					8.5	10.0
ZnO	4.8		0.5	4.0		
PbO				57.0		
BaO					3.3	
TiO_2	24.8		23.0		25.7	20.0
Nb_2O_5	22.9	22.1	29.0		19.0	27.0
WO_3		45.7				
La_2O_3				0.5		
ZrO_2				0.2		
CaO				4.0		
Sb_2O_3				0.3		
As_2O_3			0.5			
n_d	1.8178	1.7874	1.7982	1.774	1.8055	1.81491
ν_d	21.8	24.1	23.1	29.9	25.2	24.6
Tg	—	577	596	392		
Ts	—	608	622	428	520	546
L・T	熔解中失透	950	1050 <		1050 <	熔解中失透
軟化点失透性		透明	失透		失透	

【0041】

【表4】

	比較例				
	7	8	9	10	11
P_2O_5					
B_2O_3					
GeO_2	9.0	10.0	5.0	3.5	9.0
SiO_2	13.0	15.0	19.0	19.0	15.0
Li_2O		2.0	1.0		1.3
Na_2O	16.0	10.0	10.0	12.0	9.0
K_2O	10.0			9.0	9.2
Ca_2O		15.0	19.0	8.5	8.5
ZnO					
PbO					
BaO		5.0			3.3
TiO_2	27.0	25.0	25.0	26.5	25.7
Nb_2O_5	25.0	18.0	21.0	21.5	19.0
WO_3					
La_2O_3					
ZrO_2					
CeO					
Sb_2O_3					
As_2O_3					
n_d	1.80516	1.82633	1.79850	1.78946	1.80832
ν_d	24.5	24.8	25.2	25.0	25.2
Tg					
Ts	520	537	543	550	542
L・T	熔解中失透	熔解中失透	1010	1025	1050 <
軟化点失透性			失透	失透	失透

【００４２】比較例の各ガラスと比較して、表１及び２に示すように、実施例１～１４の本発明のガラスは、高屈折率かつ高分散の低融点ガラスである。さらに、実施例１～１４の本発明のガラスは、ガラス屈伏点（Ｔｓ）が５７０℃以下で、ガラスの液相温度（Ｌ・Ｔ）はすべて９５０℃以下であり、軟化点付近でガラスを３０分間保持してもガラスは失透することがなかった。従って、いずれのガラスも精密プレスによるレンズを大量に生産することが可能な安定性を有することが分かる。

【００４３】実施例２１～３０

本発明の低融点光学ガラス（第２の態様）の調合組成（重量％）及び光学的性能を表５及び６に示す。各ガラスの原料は、P_2O_5 の場合H_3PO_4 であり、Na_2Oの場合Na_2CO_3であり、K_2Oの場合KNO_3であり、Li_2Oの場合Li_2CO_3であり、Al_2O_3の場合$Al(OH)_3$であり、MgOの場合$MgCO_3$であり、CaOの場合$CaCO_3$であり、SrOの場合$Sr(NO_3)_2$であり、BaOの場合$BaCO_3$であり、B_2O_3の場合H_3BO_3である。その他の成分については、表５及び６に示した酸化物をそのまま使用した。表５及び６の実施例２１～３０に示した各ガラスは、定められた組成によって調合した後、白金坩堝を用いて１０００℃～１２００℃で熔解した。３０～４０分熔解し均質化した後、金型に鋳込み徐冷することにより

ガラスを得た。

【００４４】表中の屈折率（n_d）、アッベ数（ν_d）は徐冷降温速度－３０℃／ｈｒにした場合の結果である。ガラス転移点（Ｔｇ）、ガラス屈伏点（Ｔｓ）熱膨張測定機を用いて8℃／ｍｉｎで昇温した場合の結果である。又、液相温度（Ｌ・Ｔ）は４００℃～１０５０℃の温度勾配のついた失透試験炉に３０分保持し、倍率８０倍の顕微鏡により結晶の有無を観察し、軟化点付近の失透性も液相温度測定の際同時に目視により観察した結果である。

【００４５】

【表５】

	実施例				
	21	22	23	24	25
P_2O_5	23.4	28.0	21.4	21.4	21.4
B_2O_3	3.0	1.1	8.8	5.6	5.6
SiO_2	—	4.4	4.5	4.5	4.5
GeO_2	10.0	—	—	—	—
Li_2O	0.5	1.0	0.5	1.0	3.0
Na_2O	13.5	18.5	5.0	9.5	7.5
K_2O	2.8	2.0	8.8	7.0	7.0
TiO_2	6.0	9.2	—	9.2	9.2
Nb_2O_5	12.6	35.6	48.0	38.8	38.8
WO_3	19.5				
BaO	8.7				
Sb_2O_3		0.2			
Al_2O_3			3.0		
MgO				3.0	
CaO					3.0
n_d	1.69121	1.74812	1.75431	1.77520	1.77820
ν_d	30.5	25.7	25.1	26.2	26.1
Ts	565	551	562	560	550
L・T	930	930	930	920	910
軟化点失透性	透明	透明	透明	透明	透明

【００４６】

【表６】

	実施例				
	26	27	28	29	30
P_2O_5	21.4	24.4	24.4	21.4	15.4
B_2O_3	5.6	4.1	4.1	4.6	12.5
SiO_2	4.5	4.0	4.0	4.5	—
GeO_2	—	—	—	—	8.0
Li_2O	1.0	1.0	1.0	1.0	0.5
Na_2O	9.5	16.5	16.5	9.5	10.3
K_2O	7.0	4.0	4.0	7.0	—
TiO_2	9.2	9.2	9.2	9.2	5.0
Nb_2O_5	38.8	33.8	33.8	42.6	37.7
SrO	3.0				
ZnO		3.0			
Ta_2O_5			3.0		
As_2O_3				0.2	
WO_3					5.6
BaO					5.0
n_d	1.77745	1.74713	1.75138	1.81509	1.76371
ν_d	26.3	26.1	26.5	22.66	25.1
Ts	558	520	542	568	555
L・T	890	880	920	930	890
軟化点失透性	透明	透明	透明	透明	透明

【0047】前記表3の比較例1、2の特公昭56－40094号公報に記載の比較ガラスはガラス形成酸化物として、P_2O_5だけを用いているため耐失透性が悪く、ガラス屈伏点（Ts）も高い。またガラスの屈伏点を下げるのに最も効果の高いアルカリ金属酸化物としてK_2Oのみを用いているためガラス屈伏点が高く、精密プレス成形用ガラスとしては実用的でない。さらに表3及び4の比較例3～11のガラスは前記のようにそれぞれ問題点がある。

【0048】それに対して実施例21～30の本発明のガラスは、高屈折率・高分散の低融点ガラスであり、ガラス屈伏点（Ts）が570℃以下で、ガラスの液相温度（L・T）はすべて950℃以下である。実施例21～30のガラスは、軟化点付近でガラスを30分間保持してもガラスは失透することがなかった。従って、いづれのガラスも精密プレスによるレンズを大量に生産することが可能な安定性を有することが分かる。

【0049】

【発明の効果】本発明によれば、高屈折率・高分散特性を有するとともに、ガラス屈伏点が570℃以下で耐失透性を有し安定であり、かつ、成形性にすぐれた低融点光学ガラスを提供することができる。本発明の低融点光学ガラスを用いることにより、精密プレス用の成形型の寿命を延ばしてレンズを生産することが可能である。

	1	2	3	4	5	6	7
Composition	wt%	wt%	wt%	wt%	wt%	wt%	wt%
SiO2							
B2O3	2.5	2.5	12.5	0	1	2.5	5.5
Al2O3							
P2O5	4.4	24.4	17.4	14.4	18.4	19.4	15.4
Li2O	0	0	0	2	0	0	0
Na2O	7.8	10	10	10	5	20	10
K2O	0	3.8	0.8	0	7.8	2.8	12.8
Cs2O	0	0	0	0	0	0	0
MgO							
CaO							
SrO							
BaO	5	5	5	11.8	0	3	3
ZnO							
TiO2	5	2	5	4.5	0	6	6
Nb2O5	12.6	9.1	7.6	10.6	21.1	16.6	12.6
Ta2O5							
WO3	38.7	35.2	33.7	38.7	46.7	25.7	30.7
Sb2O3	0	0	0	0	0	0.2	0
As2O3	0	0	0	0	0.2	0	0
GeO2	24	8	8	8	0	4	4
合計	100	100	100	100	100.2	100.2	100

	1	2	3	4	5	6	7
Composition	mol%	mol%	mol%	mol%	mol%	mol%	mol%
SiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B2O3	4.91	4.92	21.97	0.00	2.44	4.32	9.91
Al2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P2O5	4.24	23.55	14.99	13.59	22.00	16.43	13.60
Li2O	0.00	0.00	0.00	8.99	0.00	0.00	0.00
Na2O	17.20	22.11	19.73	21.61	13.69	38.79	20.23
K2O	0.00	5.53	1.04	0.00	14.06	3.57	17.04
Cs2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BaO	4.47	4.48	4.00	10.33	0.00	2.36	2.46
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TiO2	8.55	3.43	7.65	7.55	0.00	9.03	9.42
Nb2O5	6.48	4.69	3.50	5.34	13.48	7.51	5.95
Ta2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WO3	22.80	20.80	17.77	22.35	34.17	13.32	16.60
Sb2O3	0.00	0.00	0.00	0.00	0.00	0.08	0.00
As2O3	0.00	0.00	0.00	0.00	0.17	0.00	0.00
GeO2	31.36	10.48	9.36	10.25	0.00	4.60	4.80
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	Emdobiment						
	8	9	10	11	12	13	14
Composition	wt%	wt%	wt%	wt%	wt%	wt%	wt%
SiO2							
B2O3	2.5	1	2.5	1	3.5	2.5	0
Al2O3							
P2O5	18.4	13.4	17.4	13.4	17.4	16.4	18.4
Li2O	0	0	0	0	0	0	0
Na2O	17	10	10	10.8	10	10	10
K2O	2.8	0.8	2.8	0	2.8	0.8	2.8
Cs2O	3	0	0	0	0	0	0
MgO		3					
CaO			3				
SrO				3			
BaO	3	8	6	8	0	5	0
ZnO					4		
TiO2	6	4.5	6	4.5	6	13	3
Nb2O5	12.6	12.6	12.6	12.6	12.6	10.6	16.1
Ta2O5							4
WO3	30.7	38.7	35.7	38.7	39.7	33.7	45.7
Sb2O3	0	0	0	0	0	0	0
As2O3	0	0	0	0	0	0	0
GeO2	4	8	4	8	4	8	0
合計	100	100	100	100	100	100	100

	Emdobiment						
	8	9	10	11	12	13	14
Composition	mol%	mol%	mol%	mol%	mol%	mol%	mol%
SiO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B2O3	4.53	1.91	4.75	2.02	6.75	4.62	0.00
Al2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P2O5	16.35	12.54	16.19	13.27	16.45	14.84	20.74
Li2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	34.59	21.44	21.31	24.49	21.65	20.73	25.82
K2O	3.75	1.13	3.93	0.00	3.99	1.09	4.76
Cs2O	1.34	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	9.90	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	7.07	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	4.07	0.00	0.00	0.00
BaO	2.47	6.95	5.18	7.35	0.00	4.20	0.00
ZnO	0.00	0.00	0.00	0.00	6.60	0.00	0.00
TiO2	9.47	7.49	9.92	7.92	10.08	20.91	6.01
Nb2O5	5.98	6.30	6.26	6.67	6.36	5.12	9.70
Ta2O5	0.00	0.00	0.00	0.00	0.00	0.00	1.45
WO3	16.69	22.17	20.33	23.46	22.97	18.67	31.53
Sb2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GeO2	4.82	10.17	5.05	10.75	5.13	9.83	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	21	22	23	24	25	26	27
Composition	wt%	wt%	wt%	wt%	wt%	wt%	wt%
SiO2	0	4.4	4.5	4.5	4.5	4.5	4
B2O3	3	1.1	8.8	5.6	5.6	5.6	4.1
Al2O3	0	0	3	0	0	0	0
P2O5	23.4	28	21.4	21.4	21.4	21.4	24.4
Li2O	0.5	1	0.5	1	3	1	1
Na2O	13.5	18.5	5	9.5	7.5	9.5	16.5
K2O	2.8	2	8.8	7	7	7	4
Cs2O							
MgO	0	0	0	3	0	0	0
CaO	0	0	0	0	3	0	0
SrO	0	0	0	0	0	3	0
BaO	8.7	0	0	0	0	0	0
ZnO							3
TiO2	6	9.2	0	9.2	9.2	9.2	9.2
Nb2O5	12.6	35.6	48	38.8	38.8	38.8	33.8
Ta2O5							
WO3	19.5	0	0	0	0	0	0
Sb2O3	0	0.2	0	0	0	0	0
As2O3							
GeO2	10	0	0	0	0	0	0
合計	100	100	100	100	100	100	100

	21	22	23	24	25	26	27
Composition	mol%	mol%	mol%	mol%	mol%	mol%	mol%
SiO2	0.00	8.23	9.95	8.29	8.17	8.73	7.25
B2O3	5.19	1.78	16.79	8.91	8.78	9.39	6.41
Al2O3	0.00	0.00	3.91	0.00	0.00	0.00	0.00
P2O5	19.83	22.18	20.02	16.69	16.44	17.58	18.71
Li2O	2.02	3.77	2.23	3.72	10.98	3.91	3.65
Na2O	26.20	33.56	10.71	16.97	13.20	17.87	28.97
K2O	3.58	2.39	12.41	8.23	8.11	8.67	4.62
Cs2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	8.25	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	5.83	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	3.38	0.00
BaO	6.84	0.00	0.00	0.00	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	0.00	0.00	0.00	4.01
TiO2	9.03	12.95	0.00	12.76	12.56	13.43	12.53
Nb2O5	5.70	15.06	23.99	16.17	15.93	17.03	13.84
Ta2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WO3	10.11	0.00	0.00	0.00	0.00	0.00	0.00
Sb2O3	0.00	0.08	0.00	0.00	0.00	0.00	0.00
As2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GeO2	11.50	0.00	0.00	0.00	0.00	0.00	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00	100.00

				Comparative Example		
	28	29	30	1	2	3
Composition	wt%	wt%	wt%	wt%	wt%	wt%
SiO2	4	4.5	0			22
B2O3	4.1	4.6	12.5			1.5
Al2O3	0	0	0			
P2O5	24.4	21.4	15.4	31.3	19.4	3.5
Li2O	1	1	0.5			
Na2O	16.5	9.5	10.3			
K2O	4	7	0	16.2	12.8	20
Cs2O						
MgO	0	0	0			
CaO	0	0	0			
SrO	0	0	0			
BaO	0	0	5			
ZnO				4.8		0.5
TiO2	9.2	9.2	5	24.8		23
Nb2O5	33.8	42.6	37.7	22.9	22.1	29
Ta2O5	3					
WO3	0	0	5.6		45.7	
Sb2O3	0	0	0			
As2O3		0.2				0.5
GeO2	0	0	8			
合計	100	100	100	100	100	100

				Comparative Example		
	28	29	30	1	2	3
Composition	mol%	mol%	mol%	mol%	mol%	mol%
SiO2	7.49	9.03	0.00	0.00	0.00	35.53
B2O3	6.63	7.97	22.21	0.00	0.00	2.09
Al2O3	0.00	0.00	0.00	0.00	0.00	0.00
P2O5	19.34	18.17	13.41	26.00	24.72	2.39
Li2O	3.78	4.05	2.07	0.00	0.00	0.00
Na2O	29.95	18.48	20.54	0.00	0.00	0.00
K2O	4.78	8.96	0.00	20.28	24.59	20.61
Cs2O	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.00	0.00	0.00	0.00	0.00	0.00
BaO	0.00	0.00	4.04	0.00	0.00	0.00
ZnO	0.00	0.00	0.00	6.95	0.00	0.60
TiO2	12.96	13.89	7.74	36.61	0.00	27.94
Nb2O5	14.31	19.33	17.54	10.16	15.05	10.59
Ta2O5	0.76	0.00	0.00	0.00	0.00	0.00
WO3	0.00	0.00	2.98	0.00	35.64	0.00
Sb2O3	0.00	0.00	0.00	0.00	0.00	0.00
As2O3	0.00	0.12	0.00	0.00	0.00	0.25
GeO2	0.00	0.00	9.46	0.00	0.00	0.00
合計	100.00	100.00	100.00	100.00	100.00	100.00

Table 8

Example	λ_5(nm)	λ_{80}(nm)
Ex.78	375	470
Ex.79	371	475
Ex.80	371	478
Ex.81	371	487
Ex.82	371	490
Ex.83	371	488

Table 8で
λ_{80}の数値とλ_5の数値が
入れ替わっています。
光学ガラスでは $\lambda_{80} > \lambda_5$ となることは
周知ですので、明らかな誤記として
補正をお願いします。

[0081]

(1) Refractive index [nd] and Abbé number [vd]

These were measured for optical glass obtained at a gradual cooling temperature reduction rate of -30°C/h.

(2) Transition temperature [Tg] and yield point temperature [Ts]

These were measured at a rate of temperature rise of 4°C/min with a thermomechanical analyzer from Riguku Denki K.K.

(3) Liquid phase temperature (LT)

The optical glass was kept in a loss of transparency test furnace with a 400-1,100°C temperature gradient, the presence or absence of crystals was observed with a microscope at 80-fold magnification, and the liquid phase temperature was measured.

(4) Viscosity at liquid-phase temperature

The viscosity at the liquid phase temperature was measured by the rotating cylinder (Margules) method (Naruse, Habuku, "Glass Engineering" (Kyoritsu Shuppan).

[0082]

Comparative Examples 1-3

Comparative Examples 1-3 are Embodiment 9 described in Japanese Patent Unexamined Publication No. Sho 55-37500, Embodiment 4 described in Japanese Patent Unexamined Publication No. Sho 56-40094, and Embodiment 1 described in Japanese Patent Unexamined Publication No. Hei 5-51233. These glasses are given as comparative examples. The characteristics of these glasses were measured in the same manner as for the embodiments. The results are given in Table 9.

Additional claims to be submitted in US09/893,958

Claims below are all new claims

117. An optical glass comprising, as molar percentages,

12-34 percent of P_2O_5;

0.2-15 percent of B_2O_3

(where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent);

2-40 percent of WO_3;

0-25 percent of Nb_2O_5;

0 to 10 percent of TiO_2

(where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent);

0-25 percent of BaO;

0-20 percent of ZnO

(where the total quantity of BaO and ZnO is less than 30 percent);

2-30 percent of Li_2O;

2-30 percent of Na_2O;

0-15 percent of K_2O

(where the total quantity of Li_2O, Na_2O, and K_2O is 29-45 percent);

0-10 percent of CaO;

0-10 percent of SrO;

0-5 percent of Al_2O_3;

0-5 percent of Y_2O_3;

0-1 percent of Sb_2O_3; and

0-1 percent of As_2O_3;

where the total quantity of all of the above-listed components is equal to or more than 94 percent; and

wherein said optical glass has comprises, as essential components, P_2O_5, B_2O_3, WO_3, Nb_2O_5, TiO_2, BaO, ZnO, Li_2O, Na_2O and K_2O; and does not comprise an amount of GeO_2.

This claim is supported by originally filed claims 15, 18 and 26, and the underlined part was derived from originally filed claims 18 and 26. Please note that in originally filed claims 15, it is defined to 2-45 percent of WO_3 but in the above claim it is defined to 2-40 percent of WO_3. This is supported by the description on page 14, line 5.

118. An optical glass comprising, as molar percentages,

12-34 percent of P_2O_5;

0.2-15 percent of B_2O_3

(where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent);

2-40 percent of WO_3;

0-25 percent of Nb_2O_5;

0 to 10 percent of TiO_2

(where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent);

0-11 percent of BaO;

0-20 percent of ZnO

(where the total quantity of BaO and ZnO is less than 30 percent);

2-30 percent of Li_2O;

2-30 percent of Na_2O;

0-15 percent of K_2O

(where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent);

0-10 percent of CaO;

0-10 percent of SrO;

0-5 percent of Al_2O_3;

0-5 percent of Y_2O_3;

0-1 percent of Sb_2O_3; and

0-1 percent of As_2O_3;

where the total quantity of all of the above-listed components is equal to or more than 94 percent; and

wherein said optical glass has comprises, as essential components, P_2O_5, B_2O_3, WO_3, Nb_2O_5, TiO_2, BaO, ZnO, Li_2O, Na_2O and K_2O; and does not comprise an amount of GeO_2.

This claim is supported by originally filed claims 16, 19 and 27, and the underlined part was derived from originally filed claims 19 and 27. Please note that in originally filed claims 16, it is defined to 2-45 percent of WO_3 but in the above claim it is defined to 2-40 percent of WO_3. This is supported by the description on page 14, line 5.

119. The optical glass of claim 117 wherein said optical glass has the composition comprising Sb_2O_3.

120. The optical glass of claim 118 wherein said optical glass has the composition comprising Sb_2O_3.

These claims are supported by originally filed claims 18 and 19.

121. The optical glass of claim 117 wherein the content of TiO_2 is 2 percent or more.

122. The optical glass of claim 117 wherein the content of K_2O is 1 percent or more.

123. The optical glass of claim 118 wherein the content of TiO_2 is 2 percent or more.

124. The optical glass of claim 118 wherein the content of K_2O is 1 percent or more.

Claims 121 and 123 are supported by [0027] and claims 122 and 124 are supported by [0029] of the application.

125. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than 0.4 Pa · s, wherein said optical glass has the

composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

126. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

127. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, and TiO_2, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O; and 0-30 percent (excluding 30

percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

128. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, and TiO_2, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O; and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

129. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, dose not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

130. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than 0.4 Pa • s, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

131. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

132. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, and TiO_2, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

133. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, and TiO_2, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1

percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

134. An optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, TiO_2, and K_2O, does not comprise substantial amount of GeO_2, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

135. An optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, Nb_2O_5, WO_3, TiO_2, and K_2O, not comprising substantial amount of GeO_2, and comprising, as molar percentages, 15-30 percent of P_2O_5; 0.5-15 percent of B_2O_3; 5-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 95 percent.

136. The optical glass of any of claims 133 to 135 wherein said optical glass comprises 0-25 molar percent (excluding 0 molar percent) of BaO.

137. An optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, Nb_2O_5, WO_3, TiO_2, and K_2O, not comprising substantial amount of GeO_2, and comprising, as molar percentages, 15-30 percent of P_2O_5; 0.5-15 percent of B_2O_3; 5-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; not more than 10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 0 percent and 30 percent) of at least one RO selected from among BaO, ZnO, and SrO.

138. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-40 molar percent of WO_3.

139. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-9 molar percent of TiO_2.

140. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 1-5 molar percent of K_2O.

141. The optical glass of any of claims 125 to 137 wherein said optical glass comprises 2-40 molar percent of WO_3, 2-9 molar percent of TiO_2, and 1-5 molar percent of K_2O.

142. An optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O;

2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent; a density of oxygen atoms contained is in the range of from 4.2×10^{22} to $5.2 \times 10^{22}/cm^3$, as well as not comprising substantial amount of GeO_2.

143. An optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 29-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent, as well as not comprising substantial amount of GeO_2.

144. An optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2 to 10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-11 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent, as well as not comprising substantial amount of GeO_2.

145. An optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, Nb_2O_5, TiO_2, BaO, ZnO, Li_2O, Na_2O and K_2O or the composition comprising the above essential components and Sb_2O_3, and comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent (excluding 0 percent) of Nb_2O_5; 0 to 10 percent (excluding 0 percent) of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent (excluding 0 percent) of BaO; 0-20 percent (excluding 0 percent) of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent (excluding 0 percent) of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); and 0-1 percent of Sb_2O_3; where a density of oxygen atoms contained is in the range of from 4.2×10^{22} to $5.2 \times 10^{22}/cm^3$.

146. An optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, Nb_2O_5, TiO_2, BaO, ZnO, Li_2O, Na_2O and K_2O or the composition comprising the above essential components and Sb_2O_3, and comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent (excluding 0 percent) of Nb_2O_5; 0 to 10 percent (excluding 0 percent) of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent (excluding 0 percent) of BaO; 0-20 percent (excluding 0 percent) of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent (excluding 0 percent) of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 29-45 percent); and 0-1 percent of Sb_2O_3.

147. An optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, WO_3, Nb_2O_5, TiO_2, BaO, ZnO, Li_2O, Na_2O and K_2O or the composition comprising the above essential components and Sb_2O_3, and comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of

P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent (excluding 0 percent) of Nb_2O_5; 0 to 10 percent (excluding 0 percent) of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-11 percent (excluding 0 percent) of BaO; 0-20 percent (excluding 0 percent) of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent (excluding 0 percent) of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); and 0-1 percent of Sb_2O_3.

148. The optical glass of claim 145 or 146 wherein said optical glass comprises 0-11 percent of BaO.

149. The optical glass of any of claims 142, 143, 145 and 1473 wherein said total quantity of Li_2O, Na_2O, and K_2O is equal to or more than 29 molar percent.

150. The optical glass of any of claims 143, 144, 146 and 147 wherein said optical glass has a density of oxygen atoms contained in the range of from 4.2×10^{22} to $5.2 \times 10^{22}/cm^3$.

151. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 2-9 molar percent of TiO_2.

152. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 1-5 molar percent of K_2O.

153. The optical glass of any of claims 142 to 147 wherein said optical glass comprises 2-9 molar percent of TiO_2 and 1-5 molar percent of K_2O.

154. An optical glass comprising P_2O_5, B_2O_3, WO_3, TiO_2, and an alkali metal oxide and not comprising substantial amount of GeO_2, wherein the total quantity of P_2O_5 and

B_2O_3 is 15-35 molar percent and the content of WO_3 is 2-45 molar percent, the content of TiO_2 is 2-9 molar percent, the content of Li_2O is 2-30 molar percent, the content of K_2O is 1-5 molar percent; where a density of oxygen atoms contained ranges from 4.2×10^{22} to 5.2×10^{22}/cm.

155. The optical glass of any of claims 142 to 154 wherein said optical glass exhibits a glass transition temperature equal to or less than 530°C and/or a yield point temperature equal to or less than 580°C.

156. The optical glass of any of claims 142 to 155 wherein said optical glass exhibits a refractive index in the range of from 1.7 to 2.0, an Abbé number in the range of from 20 to 32.

157. The optical glass of any of claims 142 to 156 wherein said optical glass exhibits a liquid phase temperature equal to or less than 970°C.

158. A precision press molding glass preform being composed of the optical glass of any of claims 125 to 157.

159. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher than 0.4 Pa · s, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O, and K_2O and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 1-15 percent); and 0-30 percent

(excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

160. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O and K_2O and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

161. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li2O, and Na_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 0-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

162. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, and Na_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 0-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

163. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O, and K_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3; 0-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 94 percent.

164. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a viscosity at the liquid phase temperature equal to or higher

than 0.4 Pa・s, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O, and K_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

165. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, and a glass transition temperature equal to or less than 540°C, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O, and K_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

166. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the

range of from 20 to 28.5, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, and Na_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

167. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, and Na_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 0-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

168. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.75 to 2.0, an Abbé number in the range of from 20 to 28.5, a liquid phase temperature equal to or less than 970°C, and a transmittance λ 80 is equal to or less than 500nm and a transmittance λ 5 is equal to or less than 385nm, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, TiO_2, Li_2O, Na_2O, and K_2O, and comprises, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent (excluding 0 percent) of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

169. A precision press molding glass preform being composed of the optical glass having the composition comprising, as essential components, P_2O_5, B_2O_3, Nb_2O_5, TiO_2, Li_2O, Na_2O, and K_2O, and comprising, as molar percentages, 15-30 percent of P_2O_5; 0.5-15 percent of B_2O_3; 5-25 percent of Nb_2O_5; 0-40 percent of WO_3; 2-10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 30 percent) of at least one RO selected from among BaO, ZnO, and SrO; with the total content of the above-stated components being equal to or more than 95 percent.

170. The precision press molding glass preform of claim 169 wherein said optical glass comprises 0-25 molar percent (excluding 0 molar percent) of BaO.

171. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.80 to 2.0 and an Abbé number in the range of from 20 to 32, wherein said optical glass has the composition comprising, as essential components, P_2O_5, B_2O_3, Nb_2O_5, WO_3, TiO_2, Li_2O, Na_2O, and K_2O, and comprises, as molar percentages, 15-30 percent of P_2O_5; 0.5-15 percent of B_2O_3; 5-25 percent of Nb_2O_5; 0-40 percent (excluding 0 percent) of WO_3; not more than 10 percent of TiO_2; 4-45 percent of at least one R'_2O selected from among Li_2O, Na_2O, and K_2O (where the quantity of Li_2O is 2-30 percent, the quantity of Na_2O is 2-30 percent, and the quantity of K_2O is 1-15 percent); and 0-30 percent (excluding 0 percent and 30 percent) of at least one RO selected from among BaO, ZnO, and SrO.

172. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 0-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent; a density of oxygen atoms contained is in the range of from 4.2×10^{22} to $5.2 \times 10^{22}/cm^3$.

173. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-25 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15

percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 29-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

174. A precision press molding glass preform being composed of the optical glass comprising, as molar percentages, 12-34 percent of P_2O_5; 0.2-15 percent of B_2O_3 (where the total quantity of P_2O_5 and B_2O_3 is 15-35 percent); 2-40 percent of WO_3; 0-25 percent of Nb_2O_5; 2-10 percent of TiO_2 (where the total quantity of WO_3, Nb_2O_5, and TiO_2 is 20-45 percent); 0-11 percent of BaO; 0-20 percent of ZnO (where the total quantity of BaO and ZnO is less than 30 percent); 2-30 percent of Li_2O; 2-30 percent of Na_2O; 1-15 percent of K_2O (where the total quantity of Li_2O, Na_2O, and K_2O is 10-45 percent); 0-10 percent of CaO; 0-10 percent of SrO; 0-5 percent of Al_2O_3; 0-5 percent of Y_2O_3; 0-1 percent of Sb_2O_3; and 0-1 percent of As_2O_3; where the total quantity of all of the above-listed components is equal to or more than 94 percent.

175. The precision press molding glass preform of claim 172 or 173 wherein said optical glass comprises 0-11 molar percent of BaO.

176. The precision press molding glass preform of claim 172 or 174 wherein said total quantity of Li_2O, Na_2O, and K_2O is equal to or more than 29 percent.

177. The precision press molding glass preform of claim 173 or 174 wherein said optical glass has a density of oxygen atoms contained in the range of from 4.2×10^{22} to $5.2 \times 10^{22}/cm^3$.

178. A precision press molding glass preform being composed of the optical glass exhibiting a refractive index in the range of from 1.80 to 2.0 and an Abbé number in the range of from 20 to 32, and comprising P_2O_5, B_2O_3, WO_3, TiO_2, and an alkali metal oxide,

wherein the total quantity of P_2O_5 and B_2O_3 is 15-35 molar percent, the content of WO_3 is 2-45 molar percent, the content of TiO_2 is 2-9 molar percent, the content of Li_2O is 2-30 molar percent, the content of K_2O is 1-5 molar percent, and a density of oxygen atoms contained ranges from 4.2×10^{22} to 5.2×10^{22}/cm.

179. The precision press molding glass preform of any of claims 172 to 178 wherein said optical glass exhibits a glass transition temperature equal to or less than 530°C and/or a yield point temperature equal to or less than 580°C.

180. The precision press molding glass preform of any of claims 172 to 177 wherein said optical glass exhibits a refractive index in the range of from 1.7 to 2.0, and an Abbé number in the range of from 20 to 32.

181. The precision press molding glass preform of any of claims 172 to 177 wherein said optical glass exhibits a refractive index in the range of from 1.80 to 2.0, and an Abbé number in the range of from 20 to 32.

182. The precision press molding glass preform of any of claims 172 to 181 wherein said optical glass exhibits a liquid phase temperature equal to or less than 970°C.

183. An optical part being composed of the optical glass of any of claims 125 to 157.

184. An optical part prepared by precisely press molding the precision press molding glass of any of claims 158 to 182.

Support claims 125 to 184 are shown in the table below:

	Base claim	Additional features
125	Claim 4	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
126	Claim 5	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
127	Claim 6	[0046] on page 19, [0024] on page 13, [0029] on page 16
128	Claim 6	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16
129	Claim 6	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
130	Claim 7	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
131	Claim 8	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
132	Claim 9	[0046] on page 19, [0024] on page 13, [0029] on page 16
133	Claim 9	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16
134	Claim 9	[0073] on page 28, [0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
135	Claims 10 and 11	[0046] on page 19, [0024] on page 13, [0029] on page 16, [0027] on page 14
136	Claim 12	
137	Claim 13	[0046] on page 19, [0024] on page 13, [0027] on page 14
138		[0060] on page 23
139		[0029] on page 16
140		[0027] on page 14

141		[0060] on page 23, [0029] on page 16, [0027] on page 14
142	Claim 14	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
143	Claim 15	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
144	Claim 16	[0060] on page 23, [0029] on page 16, [0027] on page 14, [0046] on page 19
145	Claim 17	[0060] on page 23
146	Claim 18	[0062] on page 23
147	Claim 19	[0062] on page 23
148	Claim 20	
149	Claim 21	
150	Claims 22 -24	
151		[0029] on page 16
152		[0027] on page 14
153		[0029] on page 16, [0027] on page 14
154	Claim 23	[0046] on page 19, [0029] on page 16, [0027] on page 14
155	Claim 29	
156	Claims 30-33	
157	Claim 34	
158		Precision press molding glass preform of claims 125-157
159		Precision press molding glass preform of claim 125 wherein Li_2O and Na_2O are essential components, WO_3 is an optional component, and GeO_2 is not mentioned.
160		Precision press molding glass preform of claim 126 wherein Li_2O and Na_2O are essential components, WO_3 is an optional

		component, and GeO_2 is not mentioned.
161		Precision press molding glass preform of claim 127 wherein Li_2O and Na_2O are essential components, WO_3 is an optional component, and GeO_2 is not mentioned.
162		In claim 161, a liquid phase temperature is further defined.
163		Based on [0027] on page 14, the content of K_2O is defined as 1-15 percent in claim 161.
164		Precision press molding glass preform of claim 130 wherein Li_2O and Na_2O are essential components, WO_3 is an optional component, and GeO_2 is not mentioned.
165		Precision press molding glass preform of claim 131 wherein WO_3 is an optional component and GeO_2 is not mentioned.
166		Precision press molding glass preform of claim 132 wherein WO_3 is an optional component, and GeO_2 is not mentioned.
167		In claim 166, a liquid phase temperature is further defined.
168		Based on [0027] on page 14, the content of K_2O is defined as 1-15 percent in claim 167.
169		Precision press molding glass preform of claim 135 wherein Li_2O and Na_2O are essential components, WO_3 is an optional component, and GeO_2 is not mentioned.
170		Originally filed claim 12
171		Precision press molding glass preform of claim 137 wherein Li_2O and Na_2O are essential components, and GeO_2 is not mentioned. Based on [0017] on page 11 and originally filed claims 30 to 33, a refractive index and an Abbé number are further defined.
172		Precision press molding glass preform of claim 142 wherein GeO_2 is not mentioned.

173		Precision press molding glass preform of claim 143 wherein Li_2O and Na_2O are essential components, and GeO_2 is not mentioned.
174		Precision press molding glass preform of claim 144 wherein GeO_2 is not mentioned.
175		Originally filed claim 20
176		Originally filed claim 21
177		Originally filed claims 22 to 24
178		Precision press molding glass preform of claim 154 wherein GeO_2 is not mentioned. Based on [0017] on page 11 and originally filed claims 30 to 33, a refractive index and an Abbé number are further defined.
179		Originally filed claim 29
180		Originally filed claims 30-33
181		[0017] on page 11, Originally filed claims 30-33
182		Originally filed claim 34
183		Optical part of claims 125-157
184		Optical part prepared by precisely press molding the precision press molding glass of any of claims 158 to 182.